09/868538
PTO/PCT Rec'd 19 JUN 2001
3

Description

Capacitive Magnetic Field Sensor

A plurality of magnetic field sensors is known, which are based on the Hall or magnetoresistive effect. These magnetic field sensors are extremely temperature dependent, and for this reason they are not well suited for high-precision applications or else require very expensive electronic or electrical temperature corrections.

Furthermore, capacitive sensors are customarily used for measuring pressures or accelerations. These generally prove to be mechanically very stable and have small exterior dimensions.

It is the object of the invention to create a magnetic field sensor which depends less on interfering temperature effects.

According to the invention, this object is achieved by the characteristics specified in Claim 1.

The inventive capacitive magnetic field sensor has two electrodes, which are spaced apart from one another and which form a measurement capacitance. The first electrode is situated on a first substrate body, and the second electrode on a second substrate body. The second substrate body is designed as a deformable membrane in the vicinity of the second electrode, and has a magnetic body, which is rigidly connected to the membrane and to the second electrode. If the magnetic body is caused to change its position by an external magnetic field, this change of position is imparted to the membrane and to the second electrode through the rigid connection between the magnetic body, the membrane, and this second electrode. The distance between the two electrodes is thus changed, so that the measurement capacitance of the sensor

changes as a function of the external magnetic field. This yields a reliable measurement of the magnetic field strength through the change of the capacitive properties of the sensor. This type of structure of the magnetic field sensor significantly reduces its temperature dependence, since the elastic properties of the capacitive sensor here are much less subject to temperature dependencies than the prior art sensors based on the Hall or magnetoresistive effect. Furthermore, the inventive capacitive magnetic field sensor proves to be mechanically very stable, not prone to trouble, and also has small external dimensions.

Advantageous designs of the capacitive magnetic field sensor are presented in the subclaims. In particular, it proves to be especially advantageous to situate the second electrode and the magnetic body on different sides of the membrane. This excludes a mechanical or electrical direct effect of the magnetic body through the second electrode due to the membrane which separates them. Also, this advantageous arrangement also proves to make manufacture of the sensor much easier, since the two sides of the membrane can be subjected to different production processes, which cannot mutually influence or disturb one another through their mechanical separation by the membrane.

The production process for the capacitive magnetic field sensor is thus simplified and made economical.

The magnetic body advantageously is constructed as a thin, flat layer, whose surface is joined to the membrane. This surface connection produces a very rigid arrangement of a layer-like magnetic body, the membrane, and the second electrode. This rigid structure of the various materials markedly reduces the mechanical temperature dependence of the properties of the capacitive sensor.

Furthermore, this layer can be applied very easily in the manner of an electrochemical deposition process, comparable to the process for applying printed circuits to circuit boards. This makes it possible to produce a layer with a defined thickness very easily, and assures that a defined quantity of magnetic material is used for the magnetic body, a quantity which is sufficient to influence the position of the magnetic body adequately through the action of an external magnetic field and thus to determine the magnetic field strength. The use of ferromagnetic material has here proven to be especially beneficial. Such material can be applied very simply and securely by appropriately designing the deposition method.

According to a preferred embodiment of the capacitive magnetic field sensor, an electronic arrangement for processing the measurement signals is integrated into at least one of the substrate bodies. This integration takes the form of an integrated circuit. This assures that, in addition to the extremely compact structure of the capacitive sensor, an electronic very advantageous arrangement for evaluating the measurement signals is also present, which is especially characterized by low loss power in the path from the actual capacitive magnetic field sensor to the arrangement for processing the measurement signals and thereby also has an especially good signal-to-noise ratio, and thereby provides a very differentiated evaluation and representation of the magnetic field strength. This inventive capacitive magnetic field sensor thus proves to be an extremely compact and reliable magnetic field sensor with high resolution. Such sensors are especially important in the automobile industry, where very limited space is generally available.

The electronic arrangement for processing the measurement signal preferably is situated in the first substrate body below the

electrode that is affixed thereto. This structure in the mechanically rigid, immobile first substrate body also assures a mechanically trouble-free electronic arrangement for processing the measurement signals. This significantly extends the field of application of this capacitive magnetic field sensor, and makes it especially suitable for the automobile industry or the aircraft industry.

It is especially advantageous to divide the electronic arrangement for processing the measurement signals and to situate the parts separately in the two different substrate bodies. Here, too, the electronic arrangement preferably is designed in the manner of an integrated circuit. Through this division, electronic functional groups such as amplifiers, evaluation units, or control units can be electronically decoupled from one another, and thus a cross talk from one functional group to the other functional group can be prevented. Precisely in the case of very weak signals with especially poor signal-to-noise ratio, very accurate measurement results for the field strength nevertheless can be calculated and displayed, since now this arrangement for processing the measurement signals markedly reduces any impairment of the measurement results due to cross talk between amplification, evaluation, etc.

It has proven especially suitable to design the capacitive magnetic field sensor so that at least one of the electrodes is formed by conductor tracks on the respective substrate, which preferably are part of the electronic arrangement for processing the measurement signal. Through this design, the electrodes can be produced very simply, and their form and dimension can be specifically adapted to the particular requirements. This yields a very compact, very reliable, and high-resolution capacitive magnetic field sensor. When the conductor track

of the electronic arrangement is used both as electrode and as electronic element, it becomes possible to achieve a high degree of integration for the overall arrangement and to use this conductor track synergetically.

An especially advantageous capacitive magnetic field sensor has an electrode whose spatial structure makes it able to provide still more spatial resolution of the arrangement of the electrodes relative to one another, beyond their pure distance from one another. This makes it possible to show and make available to the user not only the pure magnetic field strength but also the orientation of the magnetic field or the time- or space-change of the magnetic field, by means of a space-resolving measurement. This aspect comes especially to bear when the two electrodes are not disposed parallel to one another through an external influence, e.g. the pattern of the magnetic field or the time- or space-change of the magnetic field, but rather are situated at an angle to one another and this angle changes through the flexible design of the membrane and/or the motion of the electrodes relative to one another. Such changes prove very useful to the user of the capacitive magnetic field sensor, since he obtains further information about the time or space behavior of the external magnetic field. Such information especially allows conclusions regarding the further actuation and/or amplification of the measurement signals. It has proven especially advantageous to dispose the electronic arrangement for the space-resolving processing of the measurement signals of the spatially structured electrode of the electronic arrangement for processing the measurement signals in one or in both substrates. Here, too, this arrangement proves to be especially advantageous both in terms of production engineering and as regards the compactness of the capacitive magnetic field sensor as well as regards its mechanical stability.

An embodiment of the invention is shown in the drawing and will be described in more detail below.

Figure 1 schematically shows the structure of the capacitive magnetic field sensor. The capacitive magnetic field sensor 1 has a first electrode 2, which is situated on a first substrate body 4. A second electrode 3 is associated with the first electrode 2, and is situated at a distance therefrom. It is affixed to a second substrate body 5. The second substrate body 2 [sic] is designed as a membrane in the vicinity of the second electrode 3. In this way, the distance between the two electrodes 2 and 3 can change under the action of a force on the membrane, more or less depending on the type and hardness of the membrane. In this capacitive magnetic field sensor, a magnetic body 6 is situated on the backside of the membrane, that is on the side which faces away from the second electrode 3. Depending on an external magnetic field, said magnetic body applies a defined force on the membrane and thus moves the membrane together with the second electrode 3, thereby changing the distance between the two electrodes 2 and 3. This change of distance causes a change in the capacitance of the arrangement consisting of the two electrodes 2 and 3. This change of capacitance is amplified and evaluated by an arrangement (not shown here) for processing the measurement signals in the first substrate 4. The inventively realized concept of the magnetic field sensor thus makes it possible to measure the field strength of the external magnetic field very reliably, without strong temperature dependencies.

List of Reference Symbols

1 Capacitive magnetic field sensor

2 First electrode

3 Second electrode

4 First substrate body

5 Second substrate body

6 Magnetic body